Faculty of Engineering

REMOVAL OF HEAVY METAL FROM PLATING INDUSTRIAL WASTEWATER BY SAGO WASTE USING COAGULATION METHOD

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Bachelor of Engineering with Honours
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This declaration is made on the 26 day of May 2017.

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APPROVAL SHEET

This industrial training final report which entitled **"Removal of Heavy Metal from Plating Industrial Wastewater by Sago Waste Using Coagulation Method"** was prepared by Nur Fariheen Natasha Binti Seleman (43112) as a partial KNC4344 Final Year Project 2 course fulfillment for the Degree of Bachelor of Chemical Engineering is hereby read and approved by:

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SITI HAZIRAH ADAM
(Final Year Project Supervisor)

Date: 26 May 2017

REMOVAL OF HEAVY METAL FROM PLATING INDUSTRIAL WASTEWATER BY SAGO WASTE USING COAGULATION METHOD

NUR FARIHEEN NATASHA BINTI SELEMAN

A dissertation submitted in partial fulfilment
Of the requirement for the degree of
Bachelor of Engineering with Honours
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Dedicated to our beloved parents, who always bestow us sustainable motivations and encouragements

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ABSTRACT

The purpose of this study is to investigate the potential of sago waste as a low-cost coagulant agent to remove heavy metal from plating industry and synthetic heavy metals wastewater. In order to know the effectiveness of the sago waste as coagulant agent, there are a few factors had been studied such as the performance of the sago waste on removing heavy metal from wastewater by measuring the percentage of heavy metal removal, the characterization of chemical and physical properties of the sago waste, and the capability of sago waste as coagulant agent. The characterization of the sago waste in this project was done using Fourier Transform Infrared (FTIR). FTIR analysis was used to identify the functional group of treated and untreated sago waste that will be responsible for heavy metals coagulation process. The carboxyl groups plays important roles to remove the heavy metals contain in the wastewater. Next, for sample analysis, the percentage of the heavy metal removal was measured by using Atomic absorption spectroscopy (AAS). The experiment was carried out by using jar test equipment. Factors affecting the coagulation process, such as pH and dosage were assessed. For synthetics wastewater, the best coagulant agent is NaOH sago at optimum pH 12 where it achieved 98.50% (0.28 ppm) and 97.22% (0.15 ppm) of zinc and copper removal. However, in the real wastewater, the Nickel and Copper removed are achieved up to 96% (0.02 ppm) and 90% (0.53) respectively by using untreated sago as coagulant agent and the optimum pH was at initial pH 12. But, after the jar-test, the pH was dropped to pH 9.

ABSTRAK

Tujuan kajian ini adalah untuk menyelidik potensi sisa sagu sebagai agen koagulan kos rendah untuk membuang logam berat dari industri penyaduran dan logam berat dari air sisa buatan. Untuk mengetahui keberkesanan sisa sagu sebagai agen koagulan, terdapat beberapa faktor telah dikaji seperti keupayaan sisa sagu dalam menyingkirkan logam berat daripada air sisa dengan mengukur peratusan penyingkiran logam berat, pencirian kimia dan sifat-sifat fizikal sisa sagu, dan keupayaan hampas sagu sebagai agen koagulan. Pencirian sisa sagu dalam projek ini dilakukan menggunakan *Fourier Transform Infrared (FTIR*). Analisis FTIR telah digunakan untuk mengenal pasti kumpulan berfungsi bagi *'untreated sago'* dan *'treated sago'* yang bertanggungjawab bagi proses pembekuan logam berat. Kumpulan karboksil memainkan peranan penting untuk menyingkirkanlogam berat yang terkandung di dalam air sisa. Seterusnya, untuk analisis sampel, peratusan penyingkiran logam berat diukur dengan menggunakan *Atomic absorption spectrophotometer* (AAS). Eksperimen ini dijalankan dengan menggunakan alat *Jar-Test*. Faktor yang mempengaruhi proses pengumpalan, seperti pH dan dos dinilai. Untuk air sisa buatan, agen koagulan terbaik adalah NaOH sagu pada pH optimum pH 8 di mana ia mencapai 98.50% (0.28 ppm) dan 97.22% (0.15 ppm) penyingkiran *zinc* dan *cupper*. Walau bagaimanapun, bagi air sisa dari industri, penyingkiran logam *nickel* dan *copper* dapat dicapai sehingga 96% (0.02 ppm) dan 90% (0.53 ppm) dengan menggunakan sagu tidak dirawat sebagai agen koagulan dan pH optimum adalah pada pH awal 12. Tetapi, selepas *Jar-Test*, pH itu menurun kepada pH 9.

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ABBREVIATIONS

AAS	Atomic absorption spectroscopy
ADMI	American Dye Manufactures Institute
DOE	Department of Environment
FTIR	Fourier Transform Infrared
NaOH	Sodium Hydroxide
PPE	personal protective equipment
Pt	Platinum
SEM	Scanning Electron Microscope

NOMENCLATURE

°C	Degree Celsius
%	Percentage
cm	Centimetre
FNU	Formazin Nephelometric Unit
mg/l	Milligram per litre
h	Hour
ml	Millilitre
min	Minute
mm	Millimetre
ppm	Part per million
rpm	Rotation per minute
ton	Tonne
cm^{-1}	Per centimetre

CHAPTER 1

INTRODUCTION

1.1 Introduction

The problem of water pollution in Malaysia now becomes serious pollution issues. Industries are the major source of metal pollution in rivers. There has been a growing concern in Malaysia about pollution of heavy metals in water because the heavy metals are known to be toxic and harmful to living organism. Industries such as electroplating are contribute large amount of heavy metals as pollutant to the environment. Effluents from electroplating industries is reported to contain high amounts of heavy metal ions, such as nickel, iron, lead, zinc, chromium, cadmium and copper (Tripathi & Ranjan, 2015). In addition, during plating process only 30-40% of the metals are effectively utilized while the remaining percentage is contaminates the rinse waters used during electroplating process (Konstantinos et al., 2011). Thus, it is harmful when the effluents are discharged without careful treatment. Due to their high toxicity, industrial wastewaters are strictly regulated and have to be treated before being discharged.

There are several technique have been applied for treating the wastewater contaminated by heavy metals, including chemical precipitation, coagulation-flocculation, ion-exchange, membrane separation, reverse osmosis, solvent extraction, oxidation/reduction, and electroporation. (Lu et al., 2015). Among these technologies, Coagulation–flocculation is one of the most practised technologies extensively used on industrial scale wastewater treatment (S. Ghafari et al., 2009).

The commonly used coagulating agents are inorganic salts, usually those of aluminium and iron. Although the efficiency of chemical coagulants is well known, their use is associated with high costs and environmental drawbacks (WHO, 2008). For example, the resulting elevated concentration of aluminium cation residual causes health problems such as Alzheimer's disease in humans (Divakaran and Pillai, 2001; Teh et al., 2014) and toxicity to aquatic life. However, locally available and abundant low-cost coagulant materials from agricultural waste, such as sago waste, have the potential to be developed as a media to recover heavy metals from particularly industrial plating wastewater.

Sago flour processing is one of the main activities in Sarawak, particularly in Mukah, meaning there is abundant of unused waste, which can be converted to a value-added material. Uthumporn et al (2014) reported that Malaysia is currently the largest world exporter of starch from sago (Metroxylon sago) palm with production of 47,000 metric ton/year, and 96% of the production comes from Sarawak. Sago palm trees can grow in harsh swampy peat environment (Ruddle 1977), which covers an area of 1.5 million ha, 12% of Sarawak's total land area (Tie and Lim 1977). This means a huge land area in Sarawak can be exploited as an area for sago palm plantation to boost the production of sago starch, a potential of food supply to world population; The yield of starch from sago palm was reported to be about 3 to 4 times higher than that of rice, corn or wheat, and about 17 times higher than that of cassava (Ishizaki, 1998).

This project is aimed to treat wastewater from plating industries using sago waste coagulant by jar test experiment. Sago waste will be dried and blended into powder with particulate size between 60 -100 micrometer. Dried sago waste will be dissolved in distilled water, and then mixed with wastewater to allow coagulation process. Factors affecting the coagulation and flocculation process, such as pH and dosage will be assessed. The performance of coagulation will be assessed based on the quality of treated wastewater, read in terms of reduction heavy metal removal and Turbidity.

1.2 Problem Statement

Plating Industrial wastewater includes heavy metals such as cadmium, chromium, copper, nickel, mercury, lead and zinc which is discharged directly into the environment are hazardous and cause the environmental problem. Moreover, excessive emissions of heavy metal contain in wastewater can cause harmful to human physiology and other biological systems when they exceed the tolerance levels because most of the metals are not biodegradable and tend to accumulate in living organisms which their ion are toxic and carcinogenic (Chen et al., 2010). Due to their high toxicity, industrial wastewaters are strictly controlled and have to be treated before it being discharged. In order to prevent the negative effects of these metals on humans and the environment, it is compulsory to treat these metals from wastewater before discharge.

In addition, Sarawak is the largest sago starch production in Malaysia where it contributes about 7 ton 'hampas' per day and lead to environmental problem. Therefore, it is recommended to utilize sago waste (solid) as a coagulant for water treatment which it can reduces disposal costs while alleviating potential environmental problems (Zhu et al., 2009). Moreover, by implementing the sago waste for wastewater treatment can solve two problems concurrently which are treat the heavy metal wastewater and to reduce the solid waste management issue.

1.3 Aim and Objectives of Research

The aim of this research is to remove heavy metal from plating industrial wastewater by cellulosic extracted from sago waste using coagulation method. There are three objectives have been focused in this research in order to achieve the research aim:

1. To evaluate the performance of the treated and untreated sago waste on removing heavy metal from synthetics wastewater and plating industrial wastewater.
2. To characterize physical-chemical properties of the sago waste as coagulant agent before treatment by using Fourier Transform Infrared (FTIR).
3. To analyze the optimum condition for sago waste to treat the heavy metal contain in plating industrial wastewater using coagulation method by study the performance of percentage heavy metals removal.

1.4 Research Gap

The conducted project is to study the capability of sago waste as coagulant agent in removing heavy metals in the wastewater. The coagulant agents used in this project are untreated sago and treated sago with Sodium Hydroxide. The research gap is the sago wastes are broadly studied in oil extraction but no application in heavy metals removals. Besides, the natural coagulant agent for heavy metals removal has been studied by other researchers by using Moringa oleifera seed, banana peels and etc.

1.5 Scope of Study

Coagulation technique is applied in this research to remove the heavy metal from plating industry wastewater in Samajaya Industrial Zone, Sarawak. This treatment is chosen as the wastewater treatment because it has more advantages especially lower cost since the cellulosic sago waste are utilized as a coagulant. The physical-chemical properties of the treated and untreated cellulosic sago waste were studied in order to know the capability of cellulosic sago waste to treat heavy metal wastewater. The characteristics of the wastewater from plating industry will be analyzed before and after the coagulation treatment. In addition, the effect of pH, retention time and the dosage of coagulant used will be analyzed in this research.

1.6 Schedule

The progress of the project was following the project time schedule. The overall period required for the completion of this project is done within 2 semesters 2016/2017. The details regarding the project schedule are shown in the Table 1.1 and Table 1.2.

Table 1.1 Project time schedule for FYP 1

Activity	Semester 1 2016/2017													
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
FYP Introduction: title selection	/	/	/											
Chapter 1: Introduction				/	/									
Chapter 2: Literature Review						/	/							
Chapter 3: Methodology								/	/					
Report Writing and Presentation Preparation										/	/			
Presentation												/		
FYP 1 correction													/	
FYP 1 report submission														/

Table 1.2 Project time schedule for FYP 2

Activity	Semester 2 2016/2017													
	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
Experiment	/	/	/	/	/	/	/	/						
Chapter 4: Results and Discussion									/	/	/	/		
Chapter 5: Conclusion and Recommendation													/	
Presentation Preparation														/
FYP 1 report submission														/
Presentation (29 May 2016)														

CHAPTER 2

LITERATURE REVIEW

2.1 Plating Industrial Wastewater

The rapid industrialization and urbanization in the developing countries are creating high levels of water pollution due to harmful industrial effects. Industrial wastewaters from plating industry contain various kinds of toxic substances such as cyanide, degreasing solvent, and heavy metals. It is considered as heavy metals when the elements are having atomic weights between 63.5-200.6 and a specific gravity greater than 5g per cubic centimeter (Srivastava & Majmuder, 2008). Most of the metals discharged from the plating industry such as zinc, copper, nickel, mercury, cadmium, lead and chromium are harmful to human being and animal when it is discharged without treatment as the heavy metal are non-biodegradable and tend to accumulate in the living organism and they are known to be toxic and carcinogenic (Fenglian & Qi, 2011) (Tripathi & Ranjan, 2015) (Barakat, 2011). Heavy metals can be easily absorbed by fishes due to their high solubility in the aquatic environment and may accumulate in the human body through food chain (Malik, Jain, & Anuj, 2015).

Table 2.1 shows the metal contaminant and health hazard to human and environment (Bazrafshan, Mohammadi, Ansari-Moghaddam, & Mahvi, 2015) (Hunsom, Pruksathorn, Damroglered, Vergnes, & Duverneuil, 2005) (Babel & Kurniawan, 2004). The excessively high concentration of the metals contaminated in water can result in severe health problem as in Table 2.1. For example too much zinc can cause severe health problems such as stomach cramp, skin irritation, vomiting, nausea and anemia (Oyaro, Juddy, Murago, & Gitonga, 2007). Excessively, ingestion of copper led to serious toxicological concerns such as vomiting, cramps, convulsion, even death. Nickel exceeding its critical level might bring about serious lung and kidney problems aside from gastrointestinal distress, pulmonary fibrosis and skin dermatitis. High concentration of mercury caused impairment of pulmonary and kidney function, chest pain and dyspnea. Chronic exposure of cadmium result in kidney dysfunction and high level of exposure will result in death. Lead can cause damage the central nervous, kidney, liver and reproductive system and brain functions (Naseem & Tahir, 2001) (Carson, Ellis, & McCann, 1986).

Table 2.1 Metal contaminant and health hazards

Metal contaminant	**Health hazards**
Arsenic	Carcinogenic, producing liver tumors, skin and gastrointestinal effects
Mercury	Corrosive to skin, eyes and muscle membrane, dermatitis, anorexia, kidney damage and severe muscle pain
Cadmium	Carcinogenic, cause lung fibrosis, dyspnea and weight loss
Lead	Suspected carcinogenic, loss of appetite, anemia, muscle and joint pains, diminishing IQ, cause sterility, kidney problem and high blood pressure.
Chromium	Suspected human carcinogenic, producing lung tumors, allergic dermatitis
Nickel	Cause chronic bronchitis, reduced lung function, cancer of lung and nasal sinus
Zinc	Causes short-term illness called ‘metal fume fever’ and restlessness
Copper	Long term exposure causes irritation of nose, mouth, eyes, headache, stomachache, dizziness and diarrhea

Nowadays, heavy metals are the environmental priority pollutants and are becoming one of the most serious environmental problems. Therefore, the government has established the permissible limit for industrial effluent discharge (mg/L) in order to protect water resources from polluted. Hence, industrial wastewaters have to be treated before being discharged to environment (Bertand, et al., 2011). The wastewater treatment technique are discussed more detail in the section 2.2.